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AUTHOR Useem, Elizabeth
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ABSTRACT

The relationship between high technology companies and educational institutions in northern Santa Clara County, California, a major center of technologically sophisticated industry, was studied. Attention was directed to the way that educational institutions in Silicon Valley are changing to meet the demands of a transforming technology. Over 100 interviews were conducted in 1981 with the officials from education, industry, and government, and documents were reviewed. It was found that public schools have been the least responsive and that elite institutions of higher education, especially Stanford University, have the most responsive to the demands of the high technology economy in Santa Clara Valley. Community colleges and four-year universities are making efforts to develop or expand programs congruent with the needs of science-based local industry. These institutions are struggling to find the staffing and resources needed to establish and maintain the programs. Industry managers who were interviewed generally did not believe that an infusion of funds was necessary to upgrade and redirect the public school curricula. Executives were more willing to donate funds, personnel, and equipment to community colleges and universities because students were closer in age to starting employment and because funds could be easily targeted to specific programs. Rapidly developing industries like electronics have special characteristics that create strain for industry-education relations. Undergraduate student enrollments in engineering and computer science are growing in Santa Clara Valley, but the current output of students from undergraduate and graduate programs is not keeping pace with the demands of rapidly growing industry. (SW)

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EDUCATION AND HIGH TECHNOLOGY INDUSTRY: THE CASE OF SILICON VALLEY

Summary of Research Findings

Dr. Elizabeth Useem

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1981-82 Faculty Associate, Institute for the Interdisciplinary Study of Education, Northeastern University, 404 UO, 360 Huntington Avenue, Boston, Massachusetts 02115 617-437-3785 (Home) 617-527-1247.

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The economy of industrialized nations is undergoing a profound transformation. Variously labeled the "new Industrial Revolution," the "electronics revolution," the "new information economy," the "computer revolution," and the "Age of the Integrated Circuit," the impact of advanced electronic technology has already altered products from wristwatches to office machines to space vehicles. High technology industry is the fastest growing sector of the U.S. economy and its already widespread impact promises to become even more profound in the future.[1]

This research study focuses on the relationship between high technology companies and educational institutions in California's northern Santa Clara County, a major center of technologically sophisticated industry. The area is the home of the nation's semiconductor industry, the foundation of electronics today, and one that is undergoing continuous expansion. This study explores the degree and manner in which educational institutions in Silicon Valley are changing to meet the demands of a transforming technology--a technology that may produce changes that "literally match those of the steam engine."[2] Over one hundred interviews with officials from education, industry and government were conducted between January and July of 1981, and a range of related documents was assembled.[3] A comparative study of the area near Route 128 in Massachusetts, the other major center of high technology industry, is planned for Fall, 1981.

Santa Clara Valley is an ideal place to examine the impact of new technological forces on educational practices. It is relatively self-contained, 25 miles in length and 10 miles in width (from Palo Alto to San Jose), with over 500 high technology firms which employ 17 percent of the labor force of the county (compared to 2 percent for the U.S.);[4] it is projected to employ up to one third of total employment in the county by 1985.[5] The extraordinary expansion of the electronics industry accounts for the fact that the economy of the county has been the most rapidly growing in the country since 1975, and on a per capita basis it has become California's most affluent metropolitan area.[6] Lower growth rates in the future, however, are projected partly because of a shortage of both affordable housing and of skilled personnel.[7] Local educational and training institutions have not produced graduates in technical areas nearly fast enough to keep up with the personnel demands of high technology

firms, and the formidable rise in the cost of housing in the last few years has made recruitment of outsiders increasingly difficult.[8] Given these conditions--an affluent, easily identifiable geographic area dominated by rapidly growing high technology firms experiencing a severe labor shortage[9]--one would expect educational institutions in the county to be influenced by and reasonably responsive to the changing needs of these companies. If curricula reflecting the new revolution in technology were to be found anywhere, the schools in Silicon Valley should be the place.

The responsiveness of educational institutions to local economic forces depends, of course, on the level of education. The public schools (kindergarten through twelfth grade), community colleges, and four year colleges and universities operate in varying social, financial and political contexts, and thus it is necessary to divide our discussion among these levels.

I. THE PUBLIC SCHOOLS

It was anticipated that the public schools would be the most resistant to market forces, and this expectation was confirmed by the study. If schools were indeed responsive to major changes in the corporate order today,[10] we would expect to see strong mathematics and science programs at the elementary and high school levels; expanding industrial arts and vocational courses in such fields as electronics, computers, drafting, machining and welding; and the widespread, organized adoptions of computers for student use. The evidence suggests just the opposite. The Santa Clara Valley schools are vexed by the same problems that plague schools elsewhere in California and the nation.

A variety of indicators reveal that academic achievement in California schools has dropped below the national average.[11] The state's high school dropout rate is over twice the national average;[12] achievement scores for 1979-80 twelfth graders put them in the bottom one third of students nationally in reading and written expression and in the 42-44th percentile in math;[13] the SAT scores of University of California first year students have declined faster in recent years than the national average;[14] and California students take significantly fewer academic courses compared to students in other states.[15]

Educators believe the academic decline is attributable in part to a lowering of academic requirements and expectations which occurred between the mid-1960s and early 1970s, both in the schools themselves and in the admissions standards of the University of California and the California state college system.[16] The fact that California has plummeted to a position of 44th among the states in its share of income devoted to public schools is also cited as a cause for the decline,[17] particularly since financial cuts brought about by Prosposition 13 and other measures have led to a shortening of the school day and an increase of class size in many districts. The state has one of the highest pupil-teacher ratios in the country.

Nationwide, there is increasing awareness that a crisis is developing in mathematics and science education. Enrollments in mathematics and science courses are low (especially when contrasted with those in Japan, the Soviet Union and West Germany), achievement test scores in mathematics and science have declined since the 1960s, teachers in those fields are leaving in large numbers for better paying jobs in industry, and veteran teachers are being transferred into mathematics and science courses which they are poorly prepared to instruct.[18] The pool of newly trained mathematics and science teachers is virtually nonexistent. In California, the problem is even greater since secondary students are less likely to take advanced mathematics and science courses than their counterparts in other states. According to Michael Kirst, Past President of the California State Board of Education and Professor of Education at Stanford University, 65 percent of male students and 45 percent of female students nationwide take four or more years of mathematics compared to 53 percent of California's males and 32 percent of California's female secondary students. Only 5 percent of the state's pupils take trigonometry. In science, only 15 percent of the male students and 7 percent of the females in California take three or more years of high school science, about half the comparable percentages nationwide.[19] A study of California elementary schools found that students engage in science activities on average only 44 minutes per week.[20] A report of the California State Department of Education acknowledged that on the whole, "science education is struggling in many of the schools, particularly in kindergarten through grade six."[21] Nineteen percent of the school districts in the state have made cuts in science programs and 12 percent have experienced some reduction of mathematics courses as a result of Proposition 13 budget cuts.[22]

The schools in Santa Clara Valley reflect these national and state trends. Administrators in four the the eight secondary school systems studied in the Valley reported that student enrollments were declining in either advanced mathematics or science courses, a drop exceeding the dramatic overall decline in enrollment of pupils in many of these schools. ("Students don't want to work that hard" lamented the administrator of a high school in one of the area's most affluent high schools.) Only one school official claimed that there was increasing popularity of advanced mathematics and science courses among secondary students in his district. Six of the eight high school districts surveyed are losing mathematics and science teachers to better paying jobs in industry. Many of the districts have laid off all their younger teachers, including mathematics and science instructors, as a result of budget cuts and/or declining enrollment. One large school district in the heart of Silicon Valley has laid off all teachers hired after 1968. In all of the school districts, veteran teachers who are not truly qualified to teach mathematics and science courses are being assigned to instruct them. All of the administrators interviewed agreed that it is difficult to hire newly trained teachers in the area of mathematics and science since the pool of eligible applicants is so small. Indeed, San Jose State University has graduated only nine students in the last five years qualified to teach the physical sciences in secondary school. In 1980, the University's secondary education program had three graduating students credentialed in mathematics, ten in the life sciences, and two in the physical sciences.[23] Stanford University graduated even fewer in 1981--three in science and one in mathematics. Public school administrators interviewed were also concerned about the quality of recent education graduates. Their fears are confirmed by national data showing SAT scores of 418 in mathematics and 389 in verbal aptitude among 1980 high school seniors who planned to major in education.[24]

It is important to keep in mind that the average achievement scores of Santa Clara County students are high compared with those of other California students. The school districts in the wealthiest areas--Palo Alto, Saratoga-Los Gatos, Los Altos-Mountain View, Fremont Union (which includes Sunnyvale and Cupertino)--have achievement scores that average from the 92nd to the 99th percentiles on a statewide basis. Secondary students in the area's largest school district, San Jose Unified, also rank high, near the 80th percentile, in achievement test scores. Only one of the secondary school districts studied

had test scores averaging below the 50th percentile.[25] Nevertheless, the problem of retaining and hiring qualified teachers is a growing one for most of these districts, and one that may lower future achievement levels. The magnitude of budget cuts is large and can be expected to have a depressing effect on student learning. The President of the California Teachers Associated has recently pointed out that all but three of the 33 Santa Clara County school districts rank below state and national averages in per pupil expenditures. The shortening of the school day in two districts[26], the layoffs of all librarians and counselors in another district, and the expansion of class sizes and elimination of small advanced classes in many districts are examples of the kinds of reductions that are being made.[27] This is hardly an atmosphere conducive to strengthening and expanding solid academic courses.

The condition of industrial arts courses and vocational education programs is also problematic. The educators interviewed in this field were the most pessimistic of any group surveyed in this study. Budget reductions have hit these programs especially hard. A survey by the California Teachers Association found that one out of every four school districts in the state had cut back on vocational education and industrial arts courses as a result of budget reductions associated with Proposition 13.[28] Many school districts have shortened the high school day by eliminating or making optional the sixth period, a policy that has forced reductions in industrial arts electives typically offered in that period. There is no longer a sixth period day for juniors and seniors in the San Jose Unified School District, and sixth period classes are not available to all eleventh and twelfth grade students in the East Side Union High School District in San Jose. There is little money allocated to purchase new equipment. At the Regional Vocational Center in San Jose, a highly regarded school serving six school districts which offers programs in such high demand fields as computer operating and electronics, the capital outlay budget has been slashed from approximately $85,000 to almost nothing. Lack of new equipment will soon begin to impair the quality of instruction offered at the school, including some programs useful to high technology industry such as machine shop and welding.

In the affluent northernmost part of Santa Clara County, the administrative staff of the Regional Occupational Program (ROP), which services three high school

districts,[29] has been cut from seven to one and the program has also suffered from the same extreme drop in enrollment experienced by all schools in that area. Few programs relevant to high technology employment are now offered by the ROP, and the local schools are unwilling to start new innovative industrial arts courses in the face of budget cuts and low student demand. As the local high schools cut the courses that are prerequisites for the more advanced ROP courses, usually offered at sites away from students' home high schools, the ROP courses either fall by the wayside or are taught at a more elementary level. The drop in federal funds for vocational education has also hurt these programs. Qualified teachers, lured by higher salaries in industry, are scarce and turnover is high. For example, in the North County ROP, instructors for the electro-mechanical drafting class frequently come and go, and in the last round of hiring, there was only a single applicant for the position. Moreover, a survey of the career plans of over 9,000 students in the ninth and eleventh grades in North County schools (Fremont Union, Palo Alto Unified, and Los Altos-Mountain View Union) shows no significant interest in scientific or technical careers. Like students everywhere in the U.S., the most popular career choices were performing artist, doctor, pilot, lawyer, and professional athlete. Electrical engineer ranked eleventh on the list and electronic technician placed 42nd.

There are some strong industrial arts and vocational courses relevant to careers in electronics firms such as the nationally recognized electricity/electronics curriculum of San Jose's East Side Union High School District and several programs at the Regional Vocational Center in San Jose. But efforts to disseminate the East Side curriculum elsewhere in the Valley have met with only limited success. "Education is in a dismantling mode," said one education official, lamenting the failure of other school districts to adopt such a promising curriculum. The fact that $100,000 worth of electronics equipment sits idle in a high school classroom only several miles from some of the leading high technology companies is mute testimony to the gap between high school training programs and industrial needs. More ironic, the electronics instructor, recently laid off from the high school in a round of budget cuts, now helps manage training programs for electronics technicians in a nearby semiconductor company.

One bright spot in an otherwise bleak picture is the exponential growth in

the use of microcomputers in the schools in the last three years.[30] There is a grass roots movement among interested teachers and administrators (and parents in some systems) who are enthusiastically supporting the adoption and expansion of computer curricula in the schools. Journals, newsletters, conferences and training programs for teachers in this field have abounded in the last couple of years. Educators in Santa Clara Valley are among the national leaders in organizing and promoting the use of microcomputers for educational purposes. School teachers in the county have formed the Computer-Using Educators (CUE) group which has a membership of over 700 people in 29 states. The founder of the group, William J. Wagner, has been hired full time by the Santa Clara County Office of Education to help schools establish computer curricula. The programs in some school systems (e.g. Cupertino, Palo Alto) have received national attention. All of the administrators interviewed reported that their districts were in the process of adopting or expanding microcomputer programs. Most of these districts have had to raise money from outside sources (often federal grants) or use money from School Improvement Program funds, Mentally Gifted Minor programs or parent associations to buy the computers. Few districts have enough money in their regular budgets for such purchases.

There is, however, a spotty quality to the rate of adoptions of computers for instructional purposes in the county. Some towns have elementary schools with excellent programs, but there is little or nothing available at the junior high or high school level. In other towns and cities, the high school may encourage the use of computers but there is no use of computers at lower levels in the system. This hit or miss approach, which depends very much on whether or not there is an enthusiastic, skilled teacher or administrator (or parent volunteer) in the school, contrasts with that of several other states, notably Minnesota, which has a centralized, coordinated state-wide program for instructional computers. In California there has been no real state support or leadership—educators and parents have been on their own in seeking to establish or upgrade such programs. It is remarkable that, in spite of this, there is so much excitement and effort in this area of pedagogy. Still relatively few students in the Valley have been exposed to computers on any regular basis, but, despite the gloomy predictions by many educators interviewed in this study, who cited teacher resistance and funding problems, this situation may change significantly within the next few years. If a stable source of funding were forthcoming, the rate of adoptions

would undoubtedly occur at a much faster pace.

At a time when high technology firms in Silicon Valley are anticipating a continued long range demand for scientific and technical manpower[31], it appears that the local public schools have a reduced capacity to respond to that demand. Not only are the schools constrained by fiscal austerity, they must also cope with a variety of new demands on their finances and energy--special education, bilingual instruction, competency testing and remediation in basic skills. These new mandated programs, however meritorious in their own right, limit the schools' ability to upgrade and innovate in curricular matters. Moreover, public schools have a relatively decentralized power structure and have multiple constituencies with competing demands, making it difficult to respond effectively to the needs of any interest group.[32]

Industry has been responsive in a limited way to some of these problems in the public schools in Santa Clara County in part by drawing upon the ties it has long maintained with the system. The best established ties between schools and local industry are the advisory councils mandated by state law in vocational education programs. Both industry officials and vocational educators seemed satisfied with this relationship whereby representatives from employers give advice on the organization and content of specific programs and courses. In some instances, local firms donate equipment to the schools. Many companies have participated in career days and have organized plant tours for years. Another obvious but more recent link between the firms and schools is the Industry-Education Council (IEC) of Santa Clara County, a group formed three years ago. The organization is a chapter of the Industry-Education Council of California founded eight years ago by large employers such as the Bank of America and Pacific Telephone. The Council is a voluntary association made up of representatives from business, schools (K-12, community colleges), labor, and government, and is funded by dues paid by member organizations, corporate contributions and government grants. Most observers feel that the specific programs of the group, which have mostly centered on the needs of low income youth, have been successful. They also point out that IEC meetings provide a neutral ground where educators and industry representatives can discuss mutual concerns. Almost all of those interviewed, however, believe that the IEC in Santa Clara County at this time is not a powerful vehicle for the promotion of educational change or cooperation between

industry and education. IEC officials themselves are the first to admit the difficulty of overcoming institutional inertia and cross-agency suspicions when forming a consortium to work on even a small, focused project. Some of those interviewed felt that the organization had the potential to play an important leadership role on educational matters in the Valley. Statewide, the IEC enunciated support for public education (May, 1980) shortly before the vote on Proposition 9, which would have mandated a cut in the state income tax, and the organization was able to muster the active support of eight companies (including two Silicon Valley firms) in lobbying for a 10 percent increase in the state's 1981-82 budget for public education.

Like most other businesses in the state, high technology industry has not been an active participant in shaping educational policy in the state legislature. In fact, Silicon Valley firms, with a few exceptions, have been even less concerned with public education than other business sectors. Some observers explain that these companies, many of them new and rapidly growing concerns, have been so busy developing and marketing their own products they have not had the personnel or energy to think about broader social issues. Compared with more established traditional companies, they lag in contributions to and involvement in the arts and charitable organizations. Others feel that there is so much competition among companies for personnel (and sometimes for product markets as well) that it is difficult for them to unite on questions of schooling policy—or on almost any social issue for that matter. Only recently have they been organized by the Santa Clara County Manufacturing Group to work on local needs in housing, transportation and energy. A recent statewide business-education conference sponsored by the powerful California Roundtable had few high technology participants. Similarly, these firms' absence from state IEC initiatives indicates their low profile on educational matters. The high technology companies were largely silent on Proposition 13 and Proposition 9, the two major tax cutting proposals on the ballot since 1978. An effort in the early months of 1981 by educators at San Jose State University and San Mateo County Office of Education to mobilize Silicon Valley industry support for improved science education resulted in three meetings characterized by low turnout (only 15 of 100 companies responded) and little consensus on remedies.[33]

There is some variation among the high technology companies in the intensity and scope of their interest in public education. Some firms are concerned only

with developing a specific labor supply for their company's short term needs, whereas other businesses take a broader view of school functions that stresses the need for an intelligent citizenry. Some companies make token efforts to help schools but do so only to embellish their own community image. Many in the industry want to improve ties with schools but do not know how to go beyond traditional participation in career days and plant tours. To be sure, there are some successful programs in Santa Clara Valley linking schools and industry in addition to those supported by the local Industry-Education Council. For example, IBM has in-service training days for local vocational education teachers, it sends employees to teach economics courses in junior high schools as part of "Project Business," and it takes a leadership role in "Junior Achievement" programs in high schools. Intel has donated equipment to local high schools, sponsors science fairs, and plans a more intensive effort to communicate the industry's needs to high school counselors. Seven companies in the area (and possibly as many as twelve eventually) have contributed the equivalent of $400,000 in loaned personnel and equipment to set up schools-within-a-school in two nearby San Mateo County high schools. The project, sponsored by the Mid-Peninsula Urban Coalition, will focus on teaching computer technology and electronics technology to potential high school dropouts. Signetics is planning to support an in-service summer training program in semiconductor technology for high school electronics teachers in cooperation with San Jose State University.

Of all the companies headquartered in the Valley, Hewlett-Packard is the undisputed leader in fostering industry-education ties. William Hewlett and David Packard have a longstanding personal interest in education; their interest has left its mark on company policy. David Packard, for instance, spent ten years on the Palo Alto Board of Education. Unlike most companies, Hewlett-Packard has a number of full time employees who devote substantial portions of their time to improving their contact with public schools. A committee of top executives is currently examining ways in which the firm and the industry can provide more support for public education. It has lobbied for increased expenditures of state funds for education and was the only high technology company in the Valley to donate money in opposition to Proposition 13.[34] Among other projects, it has loaned personnel and given equipment in support of a new drafting curriculum being developed at East Side Union High School District in San Jose and the programs in computer and electronics technology

sponsored by the Urban Coalition. Gifted students from high schools in the Fremont Union High School District use Hewlett-Packard labs at night for computer training classes. Intensive career awareness programs at several area high schools have been organized by the company and it has fostered an "adopt-a school" relationship at two Santa Clara high schools. Company officials have been instrumental in building the local Industry-Education Council.

With the exception of Hewlett-Packard (IBM is often mentioned), high technology firms have devoted little effort to supporting the Valley's public schools and cultivating its long-term labor supply. While company executives are increasingly concerned about personnel shortages and the deteriorating quality of public education, they do not view education as a high priority issue. Moreover, most firms do not seem sympathetic to increased state funding for schools, particularly if it leads to higher taxes. Many feel that California schools are so poorly managed that administrators would waste any additional monies that were provided. They believe that school officials are not sufficiently aware of the demand for high technology personnel and the consequent need to change school curricula and student career awareness. Some executives also claimed that school officials are difficult to work with because they are so slow to change. Many deplored the impact of teachers' collective bargaining efforts on the school environment. Rather than lobbying for an increased and stable source of funding for schools, executives would rather focus company efforts on providing support for high technology programs in specific schools. It is possible, however, that greater support for California public education may eventually be forthcoming from a newly formed task force of the California Roundtable, a group which represents the largest firms from all business sectors in the state.

A few company officials were sympathetic to the financial condition of public schools. One exasperated manager, who has long been interested in building ties to public schools, accused his company (and others) of being greedy and self-protective. "The companies are always looking for an immediate return on their investment" when they contribute to educational programs, he claimed. Indeed, one company official admitted that the firm built close ties to schools only when personnel shortages were greater, and then loosened those ties during recessionary periods. The situation is perceived much the same way by educators, who argue that industry has an overly narrow conception of education, is short-sighted and only concerned with immediate profits, and ultimately could not be

trusted. "I wouldn't count on industry for anything," said one administrator. They felt that industry had profited from Proposition 13 and had done little with those tax savings to help the schools. Educators are acutely aware that industry leaders hold them in low regard. ("Industry thinks we are monumentally screwing up" admitted one Assistant Superintendent.) Almost all of those in industry and education who have worked together on collaborative efforts point to the difficulty in overcoming these barriers that exist between them. The mutual suspicions and organizational obstacles which have characterized business-education relations over the years are nothing new. What is new is the shift in the nation's economy toward high technology and the growing demand for well educated personnel. Yet if Silicon Valley is any example, neither the schools themselves nor industry is taking major steps to strengthen existing programs or develop new ones that reflect this economic transformation.

II. THE COMMUNITY COLLEGES

The community colleges are more responsive to emerging corporate needs. The colleges are mandated to respond to local market forces, have not experienced budget cuts as severe as those of the public schools, teach increasingly older students who are aware of career opportunities in high technology firms, and have financial incentives which propel them to structure courses to fit industrial trends. There are six community colleges in Silicon Valley and all of them have a number of programs relevant to the electronics industry. Each year, the schools serve over 100,000 students whose average age is between 25 and 30. A recent study of California community colleges found that approximately one quarter of the students are real candidates for transfer to a four year college while slightly more than a third are enrolling in courses for an immediate vocational purpose.[35] Many of these are already working full time and are seeking to upgrade their skills. Many community college officials are fearful of declining enrollment in the future as they see school attendance rates plummeting in their feeder districts. In order to keep enrollments strong, they feel that they must develop or expand programs with industry. The budget cuts brought about by Proposition 13 have also led schools to seek out industry donations of equipment. A number of industry officials pointed out that as a result of

these forces, community colleges have become much more aggressive in seeking to develop more cooperative relationships with industry.

Most industry and education officials believe that community colleges are responding as well as possible to the personnel requirements of the firms in the Valley. The variety and size of programs relevant to high technology companies is impressive. Mission College was established two years ago with a mandate to coordinate programs with the neighboring electronics companies. A look at the tentative five year plan of DeAnza College[36] shows that they are very concerned with responding to local market forces. Foothill College has highly regarded technology programs, including an A.S. degree in semiconductor processing, the only one of its kind in the nation. San Jose City College has the oldest electronics technology program in the Valley and also offers a range of other courses relevant to high technology firms. The offerings at West Valley and Evergreen Community Colleges also include a number of courses and degree programs in technical areas. The fact that these schools are relatively successful in this regard may help explain why some companies have not made education a high priority issue. Enrollments in electonics technology and computer programs have increased significantly in the last few years. "We could fill up all the community colleges in the Valley with just electronics students" claimed one administrator. Several of the colleges teach approximately 1,000 students each a year in either their electronics or computer courses. All agree that even these numbers do not begin to fulfill the personnel demands of companies, but many business executives realize that financial constraints make it difficult for the colleges to do much more. Still, some argue that community colleges are even then not sufficiently vocational in orientation.

There are a variety of direct and indirect ties between local industry and community colleges. Employer advisory committees exist in all of the vocational programs, a relationship that has been a fairly satisfactory one from the point of view of both industry and education people. One college went beyond that and hired consultants from industry to develop an electronics curriculum when it was in its formative stages. A number of companies make equipment donations to the schools although the gifts are fairly sporadic and cannot be counted on by administrators. Some of these gifts have been fairly substantial--e.g. Intel donated $85,000 worth of new equipment to the electronics technology program

at Mission College when it was founded two years ago. Hewlett-Packard gave the equipment for a self-paced electronics learning laboratory to nearby College of San Mateo. Intel, National Semiconductor and Fairchild provided some of the electronics laboratory facilities at Foothill College. A few electronics companies have cooperative or work experience programs involving community college students. For example, fifty Intel employees receive released-time from the company to attend the electronics technology courses at Mission College until they receive a two year degree. Then, the students are promoted by the company and return to their full time employee status. There are also cases of companies allowing the colleges to come in and use their equipment in a course—e.g. DeAnza College uses the Kalma facilities to teach a course in computer-assisted drafting.

Another link between industry and the community colleges is provided by the large numbers of part time teachers who are "moonlighting" from their jobs in high technology firms. Some college departments rely heavily on these teachers. The Engineering and Technology division of one college, for example, employs ten full time staff and 90 to 120 part time teachers. There are obvious problems associated with such massive temporary hiring—difficulty in evaluating teaching performance, constant hiring efforts, and lack of regular faculty to develop curricula and handle department business. However, the advantages are that the teachers are up-to-date on industrial practices and curricular emphases can be shifted quickly without having to retrain tenured faculty. Oftimes, the part time instructors provide advice on updating the curriculum. It should be noted here that there are only a handful of qualified applicants for full time positions in technical departments. An opening for a professor in semiconductor processing at one school has not had a single applicant in the last year.

The community colleges have attempted to reach more students by providing courses at sites away from the campus, including company plants. Most of the companies studied offered such courses in their buildings, usually after hours, for the convenience of their employees. Sometimes the courses are part of the firm's training program. In this case, the classes are either funded by the community college as long as they are open to the public[37] or, if they are closed to company outsiders, the company pays for the course (a "contract course"). Occasionally, the company has some say in the selection of the instructor. The

colleges are eager to help provide company training in either of these two ways. The internal training programs of firms in the Valley are expanding rapidly for several reasons: the technology is changing so fast that workers must be frequently retrained; with high housing costs making recruitment from other regions difficult, it makes sense to upgrade and retain workers already on the payroll; and companies need to make up for writing and mathematical deficiencies that workers increasingly bring with them. Industry managers interviewed were evenly divided on the issue of whether community colleges should play a greater role in company training programs. According to most observers, the need for community college involvement in corporate training is greatest among small firms who cannot afford an elaborate internal training program, but there are many bureaucratic obstacles to forming training consortia among these companies. For the most part, business managers were pleased with the quality of community college courses offered in their plants although there were a couple of cases where firms felt that a school's training materials were disappointing.

In all of these ways, then, the organization and curricula of community colleges do reflect the needs of companies in Silicon Valley. The relationship between education and business is an uneasy one, however. There is a fundamental difference between the profit-oriented, shorter term goals of industry and the longer range perspective of non-profit educational organizations. Schools move slowly in hiring full time faculty and creating new programs and courses. These decisions may take as long as a year. In contrast, Silicon Valley companies change personnel and policies rapidly. In one company, the personnel director hired engineers in such quick fashion that he was forced to rely on telephone calls and telegrams rather than letters. The famed Silicon Valley management style stresses informality, innovation, a minimum of bureaucracy and a downplaying of status differences in the organization.[38] The contrast between the cubicles of top management in several leading electronics firms and the traditional offices of educators and executives in other companies is striking. It is no surprise that executives in these businesses become frustrated with what they perceive as the glacial pace of educational change. Community college educators, for their part, are cautious about fashioning programs carefully tailored to a particular company's requirements. Some feel that personnel demands are volatile and unpredictable, and that companies' support for their programs is sporadic at best. Educators' attitudes toward industry have an ambivalent quality: on the

one hand, they are critical of industry's motives and reliability but, on the other hand, they are still eager to accommodate industry's needs.

Many managers would like the community colleges to drop liberal arts requirements for the two year degree and adopt a more specifically designed vocational program, similar to those of proprietary schools. They would also prefer that the colleges offer more courses of flexible length (some a few days, others a few months), beginning and ending at times that vary from the traditional academic calendar. According to this prescription, course content would change frequently, and a particular class might be offered only once and then dropped when no longer needed. Educators, who see their schools as stable institutions with long-range plans, claim that industry does not know its own needs, articulates them poorly when it does know, and fails to develop future plans.[39] "Anyone in industry who thinks even six months into the future is a visionary" commented one electronics professor. The colleges find it difficult to respond to a corporate environment where change is endemic.

The rapidity of technological change in the electronics industry poses other problems for the community colleges as well. "Everything is in a change mode" observed one educator. All of the community college personnel interviewed felt that it was extremely difficult if not impossible for them to have state-of-the-art equipment for training purposes. Most felt that certain programs, such as computer-assisted drafting, microwave technology, and vacuum technology, would have to utilize company equipment on-site or the courses could not be developed. Yet some firms object to on-site courses using their facilities because of their fears that students will damage expensive equipment or that company secrets will be exposed. (Concern with secrecy also makes some of them wary about their employees revealing too much proprietary information when "moonlighting" as instructors.) Company donations of equipment have been helpful but insufficient to meet schools' needs. Cuts in equipment budgets since Proposition 13 have made matters worse.[40] There is also the problem of keeping full time faculty up-to-date in their area of expertise. Some schools appear to have been more successful than others in utilizing incentives to insure faculty competence.

Another obstacle to cooperation between industry and the community colleges is the rapid turnover among corporate personnel. The American Electronics Association estimates average annual turnover of personnel in electronics firms at 35 percent a year overall and as high as 59 percent in small companies.[41] "Training directors

turn over like popcorn" said the director of one technology division in a local college. Many in both industry and the community colleges report that when they tried to develop a collaborative program, it fell through because the company contact changed jobs. The turnover rate "must drive the colleges bananas" acknowleged one training official at a semiconductor company. The organization of the companies themselves is often in a state of evolution as well. Firms merge or are bought out, new ones appear overnight, and product lines appear and disappear. The stepped-up tempo of change which characterizes high technology industry intrinsically makes it difficult for schools to react in a satisfactory way.

Many companies are ambivalent about having their employees receive further training on the job or in the community colleges. They want to retain their workers, which often requires opening upward career paths for them, but then fear that upgrading will cause these same employees to jump to a better paying job at another company. Line supervisors resent losing workers for released-timed courses. During periods of expansion, employees are often required to work overtime and have to drop out of night classes. There are some firms which take a longer range view and offer employees incentives (released-time) and rewards (promotions) for completing an entire degree program or a certificated course of study. However, many firms give very little in the way of encouragement in this regard. Also, the short term interest of some companies leads them to hire students away from community college programs before they have completed the course of study. This trend helps account for the fact that the great majority of students who take courses in technical areas do not receive a two year degree. Fear of companies hiring students prior to graduation has led one college to forbid corporate recruiters from interviewing their electronics technology students. One company offered to hire all the graduates in the electronics technology program of one college sight unseen, an indicator of the intense demand for trained personnel in this field.

The operation of the California Worksite Education and Training Act (CWETA) provides a case study of the difficulties which can beset efforts of industry-education consortia to create workable programs. The $25 million dollar CWETA bill was passed in 1979 as a result of electronics industry leaders' expressions of concern to Governor Jerry Brown that community colleges were doing an inadequate job in training skilled workers. The Act provided money for community colleges to work with firms in training structurally unemployed workers for entry level

jobs in industry and for training lower level workers for more highly skilled positions. The companies were to provide facilities, released-time and, finally, a promise of jobs at the end of the training period. The California Employment Development Department (EDD) was given the job of administering the program. Almost everyone interviewed in this study felt that CWETA was not only "too little too late " (approximately 1100 electronics employees have been slated for training as technicians thus far),[42] but was also so bedeviled by bureaucratic red tape that the program was not worth the expenditure of so much time and money. Industry people criticized aspects of the curriculum of the community colleges and their rigidity in credentialing appropriate instructors, and college people felt that company-based instruction was too narrow. Many companies, caught in an industry slowdown, lost interest in participating when they realized they had to guarantee jobs to those completing the program. Both industry and education personnel criticized the coordination efforts of EDD. An exception to this general reaction is the apparent success of the $2.5 million CWETA electronics program sponsored by the College of San Mateo. Officials at the college and cooperating companies are enthusiastic about that program.

Despite these difficulties, however, there is a good deal of eagerness on both sides to develop more collaborative programs between community colleges and Silicon Valley industry. Schools and companies that have employees working full time as negotiators and brokers arranging contacts between the two institutions have the greatest success in establishing cooperative programs. It is not easy for busy representatives of different agencies in <u>any</u> sector to develop inter-organizational ties let alone build links between institutions whose goals, values and organizational structure are as variant as those studied here. Notwithstanding the budgetary and bureaucratic realities which constrain community college administrators and faculty, they appear to be moving in a direction more consonant with the evolving economic trends in the area.

III. FOUR YEAR COLLEGES AND UNIVERSITIES

While high technology firms and industry associations are increasingly worried about the responsiveness of public school and community colleges to their needs, they are most concerned about the acute shortage of engineers and computer science graduates from undergraduate and post-graduate degree programs. According to

W. Edward Lear, Executive Director of the American Society of Engineering Education, "we have what is clearly an unstable situation calling for fast corrective action if disaster is to be averted in our engineering manpower supply."[43] Nationwide, U.S. institutions of higher education in 1981 generated only one quarter of the four year computer majors sought by industry, only one tenth of the Master's graduates required and one quarter of the Ph.D.s needed.[44] California state colleges and universities conferred 299 bachelor's degrees in computer science and 2,129 bachelor's degrees in electrical engineering in 1978-79. The U.S. production of electrical engineers at all degree levels in 1980 was 17,548, about the same as the figure in 1971. Industry officials frequently cite the fact that while Japan has half the population of the U.S., it graduates more engineers and its rate of graduates is growing faster than ours.[45] Silicon Valley semiconductor campanies are particularly sensitive to this situation since they are in direct competition with Japanese enterprise. The California Employment Development Department projects an <u>annual</u> average of 1100 job openings for electrical and electronics engineers and 806 openings for computer professionals for the next five years in Santa Clara County alone.[46] Even though the three schools in the county--San Jose State University, University of Santa Clara, and Stanford University produce growing numbers of engineering and computer science graduates (as does nearby University of California at Berkeley), the supply clearly will not meet the demand.

San Jose State University supplies more engineers with bachelor's degrees to area firms than any other school. Long overshadowed by the engineering school of its eminent neighbor, Stanford, it enrolls approximately 4000 students in engineering (which includes computer science) and granted degrees to 323 undergraduates and 84 Master's graduates in 1981. (One hundred and twenty-five of the B.S. degrees and 16 of the M.S. degrees were in electrical engineering.) A leading industry figure called the school the "unsung hero of the Valley" for turning out so many graduates. About 14 percent of the University's undergraduates, whose average age is 27 to 28, are enrolled in engineering, a typical percentage for a large state university. As job opportunities in the area have soared, student interest in engineering has increased as well. Enrollments in the last seven years have more than doubled although graduate enrollments have been stable.

However, as a result of a serious shortage of full time professors, student enrollments in engineering at San Jose State are deliberately limited, an increas-

ingly common practice at schools across the country. Nationwide, almost all engineering schools and computer science programs are having difficulty recruiting engineering faculty. It is estimated that there are approximately 2500 current openings for engineering faculty in the U.S.[47] In 1980, the state college system in California lost more engineering faculty than it gained, according to one engineering dean. Significantly fewer students today are entering and completing doctoral degree programs in engineering. There are several reasons for the shortage of doctoral candidates and faculty according to a recent report of the National Science Foundation: high industry salaries prompt faculty to leave academe and discourage younger students from pursuing teaching careers; class sizes are substantially larger than before; research support is more difficult to obtain; and university facilities for research are outmoded compared with the more exciting state-of-the-art research operations available in industry.[48] Efforts by San Jose State's School of Engineering to peg faculty salaries to a higher scale than that of other professors have thus far not met with success.

San Jose State also has a Division of Technology separate from the School of Engineering that offers undergraduates and graduate degrees in industrial arts and industrial technology. Enrollment is high (520 majors) and graduates are eagerly sought by industry. Some companies hire students in the program prior to their senior year and then give the students released-time and financial aid to complete the final year. Few of the industrial arts graduates go into school teaching, preferring instead to work for companies in their training programs. Part time teachers from industry, knowledgeable about current trends in the field, teach many of the courses. The program is suffering, however, from lack of money to acquire new equipment. Officials estimate that the Division needs at least $200,000 for new purchases but had a budget of only $17,000 for that purpose in 1981.

The University of Santa Clara, a Jesuit institution with 7000 students, enrolls 600 undergraduates in its engineering and computer science programs (17 percent of the undergraduate student body) and has 1,000 students in its part time graduate program. In 1981, 80 undergraduates received a B.S. degree in engineering and computer science and 90 graduates received an M.S. degree in those fields. Like San Jose State, student majors in engineering have grown substantially in the last decade—enrollments have jumped by one third in the

last few years. The graduate Master's degree "early bird" program, running five days a week, 7 to 9 in the morning, is also increasing in size. Its courses are taught by 150 part time faculty who also hold full time jobs in industry, making them well versed in current industrial technology. Enrollment of students in undergraduate engineering courses is limited to the better students. The school is debating how much it should expand its enrollment. University officials fear that a future drop in the labor market for engineers might leave them "high and dry" if they expand too much.

Historically, Stanford University has played a crucial role in the development of Silicon Valley.[49] Indeed, rather than merely reflecting industrial changes, Stanford's School of Engineering actively created the high technology complex under the leadership of its former dean, Frederick Terman. Terman, the "father of Silicon Valley," became interested in developing science-based companies with close links to Stanford in the 1930s, to be what he referred to as a "community of technical scholars." Terman assisted in the formation of Hewlett-Packard in 1937 and he and the Physics Department provided support in the founding of Varian as well in that same year. After the Second World War, when Terman became Dean, he expanded the School of Engineering, encouraged faculty and industry people to pursue collaborative work, supported faculty in efforts to start their own companies, developed the Stanford Industrial Park which rents to high technology firms, and began a part time graduate program open to local company engineers. As Provost and, later, as Vice President of Stanford, Terman built up the Chemistry Department in a way that encouraged the formation of a new complex of companies in the area, specializing in biology and medicine. New biotechnology companies are still forming there, drawing on talent in the Medical School and related disciplines.

Stanford's reputation for national leadership and excellence in these fields remains. In 1981, the School of Engineering graduated 256 bachelor's recipients, 707 Master's degree students and 130 Ph.D.s. Approximately 18 percent of the undergraduate student body is now majoring in engineering or pre-engineering. The awarding of graduate degrees has not dropped as it has elsewhere. Stanford produces one out of every eight Ph.D.s in computer sciences in the country. The University is in the process of developing a Center for Integrated Systems (CIS) whose objective is to "train the new people, students and mid-career professionals, and to generate the new scientific and technological ideas that will be required to develop very large scale integrated systems (VLSI) to their full potential."[50]

The microelectronics center, one of the few in the United States, will coordinate efforts of several disciplines and will produce 30 Ph.D. and 100 Master's degree graduates each year who are billed as the "new breed of systems-oriented scientists and engineers." The University's School of Education is also just beginning a Master's program in interactive educational technology which will train computer software personnel for schools and industry. Ironically, however, the School of Education has almost completely abandoned its role in training public school teachers in the fields of science and mathematics.

It should be noted that the California Legislature just allocated $2.6 million to construct a microelectronics center, to be known as MICRO, at the nearby campus of the University of California at Berkeley. An additional $1 million of research funds to be matched by industry contributions was also approved. The impetus for the center came from Governor Jerry Brown and executives at Intel, National Semiconductor, and Advanced Micro Devices, all Silicon Valley semiconductor firms. This was the first year that high technology corporations began to focus on state level political action. The original proposal calling for $5 million of grants for research to be matched by industry was scaled down by the Legislature, but Brown's staff hopes that additional funding will be forthcoming in future budgets. MICRO will be run by a committee composed of equal numbers of state government, university, and electronics industry representatives. Most of the research money will fund joint industry/academic projects. Brown's desire to establish a center that will maintain and further develop his state's technological leadership in microelectronics is being duplicated in other states. The North Carolina General Assembly has appropriated $24.4 million over the next two years to establish a microelectronics center in the Raleigh-Durham area, "North Carolina's answer to Silicon Valley." The center will be affiliated with five nearby universities and, like MICRO, will be run by a committee of industry and education people. A similar center is being developed at the University of Minnesota financed by the University and major corporations in the area. Some have contributed $2 million each. Company research facilities will also be utilized in that consortium arrangement.

The ties between industry and schools of engineering are closer than those between business and other levels of the educational system. Although neither educators nor the industry people are fully satisfied with the relationship, the links are comparatively strong. Because of Stanford's intimate involvement in

the creation and expansion of electronic and bio-medical firms in the Valley, its relationship with industry is close and enduring. Approximately 350 employees from 50 area companies are enrolled in the Stanford Honors Co-op Program, a part time Master's program taught partly through an interactive television system located in the companies themselves. The companies pay their employees' tuition, double the normal fee, and provide released-time. Auditors and "non-registered options" (students who take the course including examinations, but receive no credit for it) are also allowed, for a fee, so the courses reach several thousand students. Professors grumble about the additional workload these latter students generate and companies complain that so few of their employees are accepted into the highly selective Co-op program. Stanford refuses to expand the enrollment of students. The percentage of Stanford engineering graduate students who are supported by business has gone "up, up, up" in the words of one school official, so that now between 25 and 35 percent of the students have their tuition paid by industry. Because of Stanford's selectivity and high tuition, several Silicon Valley firms are also developing a similar part time degree program with the University of California at Berkeley.

In addition to ties with industry through faculty consulting, student hiring and the Co-op Program, Stanford runs an Industrial Affiliates Program which brings in $1 to 2 million a year to the School of Engineering. In exchange for having a special recruitment relationship and access to information about ongoing research projects, companies donate an average of $10,000 a year to one of 15 or 16 subgroups of faculty. Each subgroup has some ten contributing companies associated with it, and the faculty can use the funds for whatever professional purpose they wish (equipment, travel, fellowships, etc.). The School also has an Advisory Board that includes top industry representatives whose function it is to review the School's overall program. The new Center for Integrated Systems is being partially financed by corporate sponsors. Thus far, eleven companies from across the country (including Hewlett-Packard, the only Silicon Valley firm of the eleven) have each contributed $750,000 to help construct the new micro-electronics center. Ongoing research in this area is now heavily supported by the federal government but Stanford officials hope that eventually at least half of all research funds will come from industry. Companies can expect to receive several concrete benefits from their sponsorship of CIS: 1) they will be allowed special opportunities to observe the work of students at the Center and

will be given preferential treatment in recruiting them; 2) although research projects will be approved by a committee composed only of Stanford personnel, CIS will try to tailor research to the needs of companies and will make findings available to sponsors; 3) corporate staff could be temporary residents of the lab; and 4) the Center will develop state-of-the-art educational materials than can be used in company training programs. Companies which are Affiliates but not Sponsors "will receive a limited sampling of CIS activities."[51] CIS Director, John G. Linvill, believes that corporate contributions to the Center and the subsequent flow of highly trained graduates to the companies "will represent a new relationship between universities and industry, comparable in importance to that which developed between universities and the federal government following World War II."[52]

San Jose State and the University of Santa Clara also have a variety of direct ties with Silicon Valley industry. Both Schools of Engineering have Advisory Committees composed of high level company executives. The advice of these executives can be particularly valuable when new programs are being developed. San Jose State solicits corporate donations for its engineering program and has succeeded in raising several hundred thousand dollars in the last year. At Santa Clara, if donations are made, they are given to the University as a whole. San Jose State offers some graduate level engineering courses on-site at three companies. Companies make equipment donations to the schools although university officials disagree as to their usefulness. (Comments ranged from "we get junk" to "we survive off of industry.") Educators would like the companies to involve themselves more closely in engineering education and develop a deeper understanding of the problems the schools face in acquiring modern equipment and recuiting faculty.

The corporations generally devote more time and money to developing good relationships with university and four year college engineering schools and departments than they do with building ties to community college programs and public schools. Many companies have personnel assigned full time to college relations and university recruitment. Executives frequently serve on advisory boards of the schools. Companies such as Lockheed, IBM, Intel and Hewlett-Packard have been fairly active in developing ties to programs. Most of the larger firms studied have established a nationwide program of "key schools" whereby they target their equipment donations, grants and visits to schools that are most likely to meet their employment needs. These efforts to cultivate fruitful contacts sometimes

include San Jose State and the University of Santa Clara, and almost always include Stanford.

Because of the current crisis in the supply of engineering faculty, more companies are considering stepped up efforts to supplement faculty salaries by hiring them in the summer or as consultants, to loan industry personnel to teach, and to endow professorships in engineering schools. Increased equipment donations and financial contributions are also being contemplated. Electronics companies are lobbying in Washington for tax credits for corporate contributions to university research and development efforts. The American Electronics Association has established a national blue ribbon committee to formulate plans for corporate action in engineering education. The Chair of the Committee, Dr. William J. Perry, claims universities and corporations alone should deal with the crisis. He argues that government "is not the appropriate vehicle for action," an opinion shared by officials of other industry groups as well.[53] A contrary view, however, is expressed by Vincent S. Haneman, outgoing President of the American Society for Engineering Education, who believes that ultimately government will have to intervene. "The problem we face is so vast that no one in industry can meet it ... A large amount of the funds we need will have to come from public coffers."[54]

While companies are sympathetic to the financial problems of engineering and the computer science programs, executives are still critical of the colleges for not shifting more resources away from liberal arts into technical disciplines. They feel that liberal arts faculty have too much autonomy and influence in university decision-making. Faculty in traditional disciplines are seen as obstructing the development of high technology programs. However, the problems of fiscal austerity in higher education in general, the specter of declining enrollment, and fear of fluctuations in labor markets also make administrators cautious about investing heavily in expensive vocational programs without significant outside support.

In sum, contacts between high technology industry and technical programs in colleges and universities are relatively close. Undergraduate student enrollments in engineering and computer science are growing in Santa Clara Valley, but the current output of students from undergraduate and graduate programs is still not keeping up with the demands of a rapidly growing industry.

CONCLUSION

Public schools have been the least responsive and elite institutions of

higher learning, especially Stanford, have been the most responsive to the demands of the high technology economy in Santa Clara Valley. In fact, in the case of Stanford, the causal direction is reversed in part since this university played such a significant role in developing the industry to begin with. Community colleges and four year universities are making efforts to develop or expand programs that are congruent with the needs of science-based local industry. But those institutions are still struggling to find the staffing and resources needed to establish and maintain thriving programs.

The public schools, starved for funds and beset by the conflicting demands of many constituent groups, are moving in a direction opposite to the economic trends in the area. Industry appreciates the financial difficulties of community colleges and universities, but it has, with a few exceptions, little sympathy for the fiscal condition of the public schools. Managers who were interviewed did not generally believe that an infusion of funds was necessary for upgrading and redirecting school curricula. Executives were far more willing to donate funds, personnel and equipment to community colleges and universities because students were closer in age to the point of employment and because funds could be easily targeted to specific programs. Business people want a quick return on their investment, something public schools can rarely deliver. Moreover, as one prominent business leader observed, even when company executives want to help solve the problems of the public schools, "the problems are so big, so bureaucratic and complicated that you don't know where to begin." That sentiment was echoed by another executive who said simply "it's hard to know where to focus on what to do." There are a few signs that high technology companies are beginning to think more about "what to do" as they come to recognize that public schools are the core of the nation's educational system, and the system is in decline relative to that of their foreign competitors.

It is safe to say that educational institutions will never be as responsive to industrial demands as the private sector would like. And rapidly developing industries like electronics have special characteristics which make industry-education relations more strained than they would be in other corporate environments. If schooling in Silicon Valley is any example, the "new industrial revolution" may unfold a bit more slowly and unevenly than anyone thought.

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1. Christopher Evans, The Micromillenium, New York: The Viking Press, 1979; Tom Forester (ed.), The Microelectronics Revolution, Cambridge, Massachusetts: The M.I.T. Press, 1981; and Adam Osborne, Running Wild: The Next Industrial Revolution, Berkeley: OSBORNE/ McGraw Hill, 1979.

2. Christian Science Monitor, December 30, 1980, p. 1.

3. A total of 105 unstructured interviews averaging one hour in length were conducted. Most respondents (82) were seen in their offices and the rest were interviewed on the telephone. I spoke with 59 educators: administrators in ten public schools systems; administrators in eight community colleges and three universities; seven vocational education administrators; two teachers union officials; six local education leaders prominent in the field of microcomputers; seven university professors knowledgeable on this research topic; five state education officials; two leaders of national professional associations; and three administrators of groups who coordinate some industry-education activities. The 39 industry representatives interviewed were usually managers in personnel or training in seven of the ten largest companies in the Valley, all employing over 5,000 workers locally, and in five medium sized companies (between 500 and 3,000 workers). The latter five were selected at random from a complete list of local high technology firms of that size. One small (under 200 employees) "start-up" company was studied as well. In addition, representatives from four industry trade associations were interviewed as well as executives outside of training and personnel in the twelve targeted companies who were recommended as knowledgeable sources on the topic. Four government officials and one community organizer were also contacted.

4. A Robert DeHart(ed.), "Planning for the 80s ," (Draft), DeAnza College, June, 1981, p. 27.

5. California Employment Development Department, "Projections of Employment by Industry and Occupation 1980-85, San Jose Standard Metropolitan Statistical Area," Employment Data and Research Division, September, 1979, p. 15.

6. A Robert DeHart (ed.), "Planning for the 80s," (Draft), DeAnza College, June, 1981, p. 27.

7. California Employment Development Department, cited above, p. 16.

8. There is a serious job/housing imbalance. For example, according to the DeAnza Planning Report cited above (p. 24), in 1979 there were 36,000 new jobs developed but only 8,000 new housing units were built. See also Silicon Valley, Paradise or Paradox? The Impact of High Technology Industry on Santa Clara County, Pacific Studies Center, Mountain View, CA, 1977.

An extensive analysis is contained in a March, 1981, Working Paper by AnnaLee Saxenian written for the Institute of Urban and Regional Development of the University of California, Berkeley, entitled Silicon Chips and Spatial Structure: The Industrial Basis of Urbanization in Santa Clara County, California.

9. The current slowdown in the semiconductor industry has temporarily curtailed hiring in those firms. Approximately 27 percent of those employed in the electronics industry in the Valley are working in semiconductor plants. (San Jose Mercury, June 15, 1981, p. 1).

10. Revisionist educational historians and social scientists have argued that schools were shaped to fit the corporate order during and just after the period of the industrial revolution in this country. See, among others, Samuel Bowles and Herbert Gintis, Schooling in Capitalist America, New York: Basic Books, 1976; Michael Katz, The Irony of Early School Reform, Cambridge: Harvard University Press, 1968; and David Nasaw, Schooled to Order: A Social History of Public Schooling in the United States, New York: Oxford University Press, 1979.

11. Michael Kirst, Professor of Education at Stanford University and Past President of the California State Board of Education, has summarized and publicized evidence showing an academic decline in California schools. See "What's Right--and Wrong--with California Schools," Sunday Mercury News, January 18, 1981, and "Curriculum: A Key to Improving Academic Standards," prepared for the College Board Symposium on Transition from Secondary School to College, St. Louis, May, 1981. See also "What We Must Do To Save Public Education in California," paper delivered by Bill Honig, Member California State Board of Education, Conference on Public Education in California sponsored by the California Roundtable, February 10, 1981.

12. Sunday Mercury News, June 7, 1981, p. 1. Reference to a report prepared for the U.S. Department of Labor, "Why Kids Drop Out of High School," by Russell Rumberger, Stanford University, Institute for Research in Educational Finance and Governance.

13. Using 1970 norms, California students scored at the 32nd and 34th percentiles in reading, at the 27th and 28th percentiles in written expression, and at the 42nd and 44th percentiles in mathematics. The findings for third and sixth graders were more positive with median scores on all subjects falling between the 50th and 60th percentiles based on national norms. These data are contained in "Student Achievement in California Schools, 1979-80 Annual Report," California Assessment Program, State Department of Education, Sacramento, CA, pp. 1,2.

14. San Jose Mercury, April 9, 1981, p. 12A. See also Michael Kirst, "Curriculum: A Key to Improving Academic Standards," pp. 4,5, cited above.

15. Michael Kirst, "Curriculum: A Key to Improving Academic Standards," cited above. Also, "Summary of Initial Discussion on Secondary Curriculum," California State Board of Education, January 10, 1980.

16. For example, admission requirements to the University of California include only four years of English, one year of history, two years of mathematics, one year of a laboratory science, two years of a foreign language, and one advanced course in foreign languages, mathematics or natural science.

17. Bill Honig, "What We Must Do To Save Public Education in California," cited above. This figure is also widely quoted in the news media.

18. Michael Kirst, "Japanese Education: Its Implications for Economic Competition in the 1980s," Phi Delta Kappan, June, 1981, pp. 707-708; Science and Engineering Education for the 1980s and Beyond, a report prepared by the National Science Foundation and the Department of Education, October, 1980, pp. 3-7. See also "Statement of Pat Hill Hubbard," American Electronics Association, before the Senate Select Committee on Small Business, February 18, 1981. It is published as "Exhibit E" in the AEA's Technical Employment Projections 1981-1983-1985, Palo Alto, May, 1981, pp. 175-196 ; "Mathematics Teacher Supply and Demand," a report of the National Council of Teachers of Mathematics, Reston, Virginia, 1981.

19. Michael Kirst, "Curriculum: A Key to Improving Academic Standards," cited above.

20. Eugene H. Brown, An Assessment of Science Programs in California Elementary Schools, doctoral dissertation, University of California, Berkeley, 1977.

21. California State Department of Education, Science Framework for California Public Schools, California State Department of Education, 1978, p. vii.

22. California Teacher's Association press release, Burlingame, CA, March 31, 1981.

23. These are unofficial figures supplied by the Natural Science Department at San Jose State University. Data are also available in the "Annual Statistical Report of Registered Education Candidates for the 1979-1980 Academic Year," Career Planning and Placement, San Jose State University. (Some students who receive their credential do not register with Career Planning and Placement.) The report notes that there has been a dramatic increase in the volume of vacancy listings and a substantial drop in teacher candidates, 747 to 352 in four years, leading them to predict a national teacher shortage in several credential areas before long.

24. Chronicle of Higher Education, March 2, 1981, p. 1; "Teachers Are in Trouble," Newsweek, April 27, 1981, p. 79. The SAT scores of college bound seniors who planned to major in education were 48 points below the national average in mathematics and 35 points lower on the verbal portion of the test. Only one other major (ethnic studies) had lower scores. Chronicle of Higher Education, May 18, 1981, p. 4.

25. California Assessment Program, California State Department of Education, "Profiles of School District Performance," Santa Clara County. There is a very close association between socioeconomic status (measured by parent education) and achievement scores of twelfth graders in the districts studied.

26. Daniel L. Duke and Adrienne M. Meckel, "The Slow Death of a Public High School," Phi Delta Kappan, Vol. 61, June, 1980, pp. 674-677.

27. A recent poll by the San Jose Mercury (April 23, 1981, p. 6B) showed that while enrollment of students has declined 10.4 percent since the passage of Proposition 13, the number of teachers has fallen by 16 percent and the number of counselors and librarians by 22 percent.

28. California Teachers Association Press Release, Burlingame, CA, March 31, 1981.

29. Fremont Union High School District, Palo Alto Unified, Los Altos-Mountain View Union High School District.

30. "Computer Use in Santa Clara County Schools," Professor Marjorie A. Fitting, Mathematics Department, San Jose State University, June, 1980.

31. American Electronics Association, Technical Employment Projections 1981-1983-1985, Palo Alto, May, 1981; California Employment Development Department, "Projections of Employment by Industry and Occupation 1980-85, San Jose Standard Metropolitan Statistical Area," September, 1979.

32. This notion is more fully developed in Christopher J. Hurn, The Limits and and Possibilities of Schooling, Boston: Allyn and Bacon, Inc., 1978, pp. 78-81.

33. The group, Science Educator Industry Cooperative, was organized by Diane Conradson of the Natural Science Department at San Jose State University and Walter Smithey of the San Mateo County Office of Education. They plan to continue the group's initiatives through the state Industry-Education Council office.

34. Data on contributions of $1,000 or more for and against Propositions 9 and 13 was obtained from the State of California Fair Political Practices Commission.

35. Russell Hunter and M. Stephen Sheldon at Los Angeles Peirce College have been conducting a three year longitudinal study of California community college students.

36. A. Robert DeHart (ed.), "Planning for the 80s" (Draft), DeAnza College, June, 1981, p. 27.

37. There were a couple of cases where a course was part of a company training program and was paid for by a community college, but was deliberately publicized in a way that prevented company outsiders from taking the class. This practice was quite the exception, however, and not the rule.

38. Gene Bylinsky, The Innovation Millionaires: How They Succeed, New York: Charles Scribner's Sons, 1976 (Chapter Three, "California's Great Breeding Ground for Industry"); "The Silicon Valley Style," Newsweek, June 8, 1981, pp. 80-83; San Francisco Chronicle, September 23, 1980, p. 1.

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40. For example, in the Foothill-DeAnza district, the budget for capital outlay for vocational programs dropped from $600,000-$800,000 in the early 1970s to $100,000 currently.

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42. The California Worksite Education and Training Act, "Report to the Legislature," December, 1980, Sacramento, CA, p. 11.

43. Quoted in Engineering Education News, April, 1981, p. 1.

44. Business Week, November 10, 1980, p. 113.

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